Intermittency Analysis Project

Task 3: 2010 Power Flow Impact Analysis

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Task 3 Objectives

- Develop WECC, Utility approved power flow data sets for 2010
- Develop a 20% renewable penetration portfolio mix
- Evaluate intermittency impacts under higher penetrations similar to Task 2

Why Study 2010 Renewables??

- Support the RPS process for increasing the penetration of renewables
- Support locating potential renewable sites within California
- Facilitate in-area generation development
- Help define transmission expansion requirements to support renewables
- Define potential problem areas and critical issues

2010 Power Data Development

- 2010 Summer, Spring and Fall
  - Define seasonal power flow simulations under various renewable penetrations, utility loads and generation dispatch
  - Evaluates the capability and reliability of the transmission system under different operating conditions

Seasonal Periods

- Data set periods
  - Summer – July on-peak
    - Summer peak load hours
  - Spring – May on-peak
    - Normally high wind and hydro generation
    - Lower utility load levels
  - Fall – November off-peak
    - No solar
    - Minimum utility load levels
    - Minimum generation problems

2010 Assumptions

- SDGE cases assumed worst configuration
  - Encina and South Bay out of service
    - Higher imports over 500 kv lines
  - Configuration changed as being replaced in kind – agreed to by SDGE and CEC
- New conventional resources to meet reserves used from CEC Electricity Analysis Office (EAO)

2010 Assumptions Cont'd

- Tehachapi transmission line expansion based on Tehachapi Collaborative Study Group recommendations (Midway to Tehachapi interconnection)
- Imperial Valley geothermal expansion similar to the IID Green Path expansion
  - 500 kV expansion representative of SDG&E and LADWP proposals

Input Data Set Summary

- Data sets consistent with EAO projections for load and generation
- Power flows were representative of IOU assumptions and projections
- Individual data sets (spring, summer and fall) were valid for resource mix and load projections

Transmission Topology Issues between Historical Year and 2010 Cases

ID numbering

Bus Names

Bus Numbering

Why is Topology Consistency Important between Years??

- Inconsistent bus numbers and bus names make it hard to insert new generation and track power flows on a consistent basis
- Reconciliation between data sets creates delays in completing studies to resolve modeling inconsistencies
- Errors more easily occur due to topology differences

Example of ID Number Inconsistencies

2010 Gen Records				Historical Year Gen Records			
Area Name	Number	Name	ID	Area Name	Number	Name	ID
PG AND E	38760	DELTA E	10	PG AND E	38760	DELTA 1	1
PG AND E	38760	DELTA E	11	PG AND E	38760	DELTA 1	2
PG AND E	38765	DELTA D	8	PG AND E	38765	DELTA 2	1
PG AND E	38770	DELTA C	6	PG AND E	38770	DELTA 3	1
PG AND E	38770	DELTA C	7	PG AND E	38770	DELTA 3	2
PG AND E	38815	DELTA B	5	PG AND E	38815	DELTA 4	1

Example of Bus Number and Name Inconsistencies

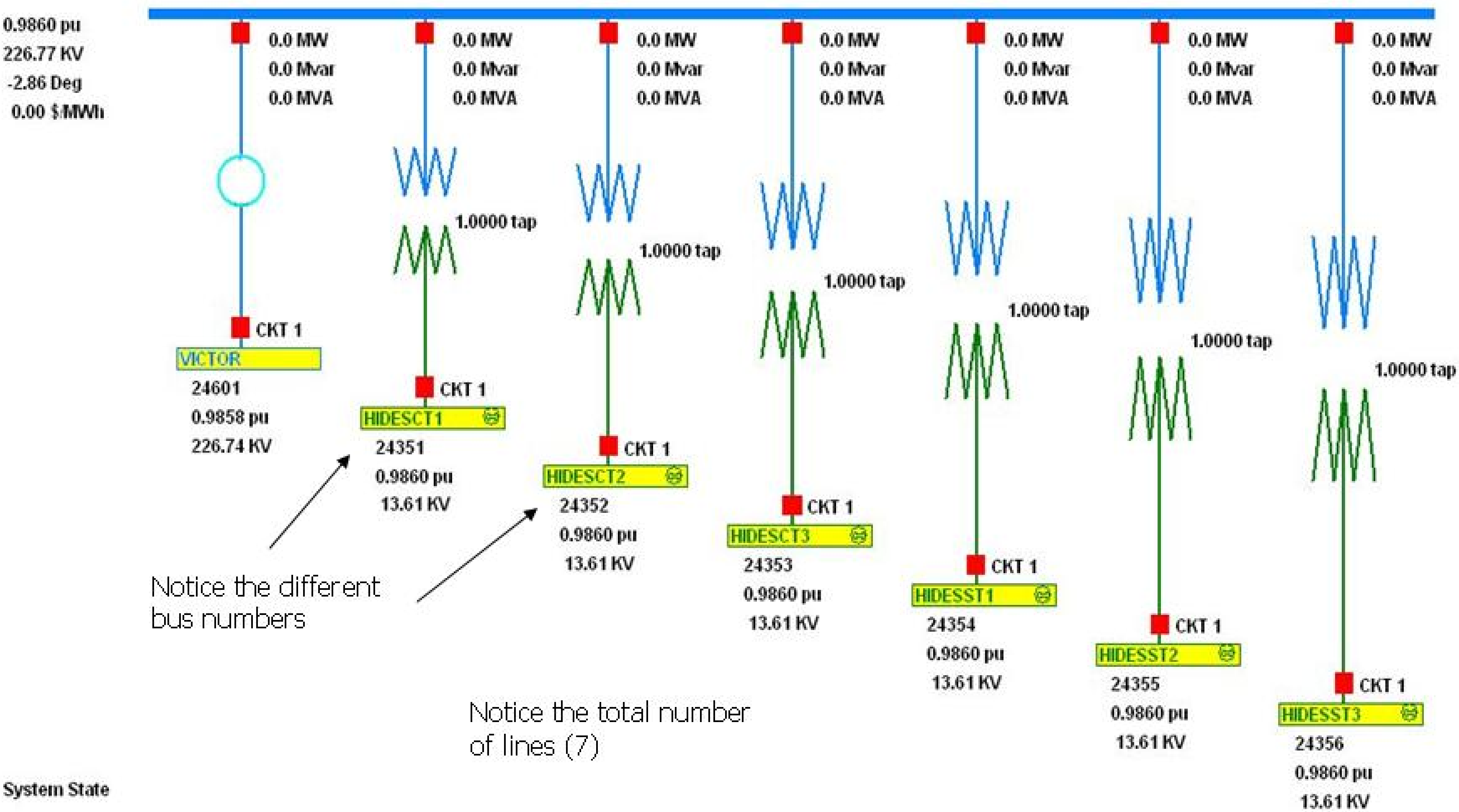
2010 Bus Names or Numbers				2006 Bus Names or Numbers			
Area Name	Number	Name	ID	Area Name	Number	Name	I D
SOCALIF	28003	HIDEDCT1	1	SOCALIF	24351	HIDESCT1	1
SOCALIF	28002	HIDEDCT2	1	SOCALIF	24352	HIDESCT2	1
SOCALIF	28001	HIDEDCT3	1	SOCALIF	24353	HIDESCT3	1
SOCALIF	28000	HIDEDST1	1	SOCALIF	24354	HIDESST1	1
SOCALIF	28503	NORTHWN D	1	SOCALIF	24462	NORTHWN D	1

Examples of Bus Name and Number

- Next two one-lines show the bus one-line for Bus 24350 (Hidesert)
- Notice the different configuration
- Notice the different bus numbering

HIDESERT

Bus: HIDESERT (24350)
Nom kV: 230.00
Area: SOCALIF (24)
Zone: 0 (0)



Notice the different bus numbers

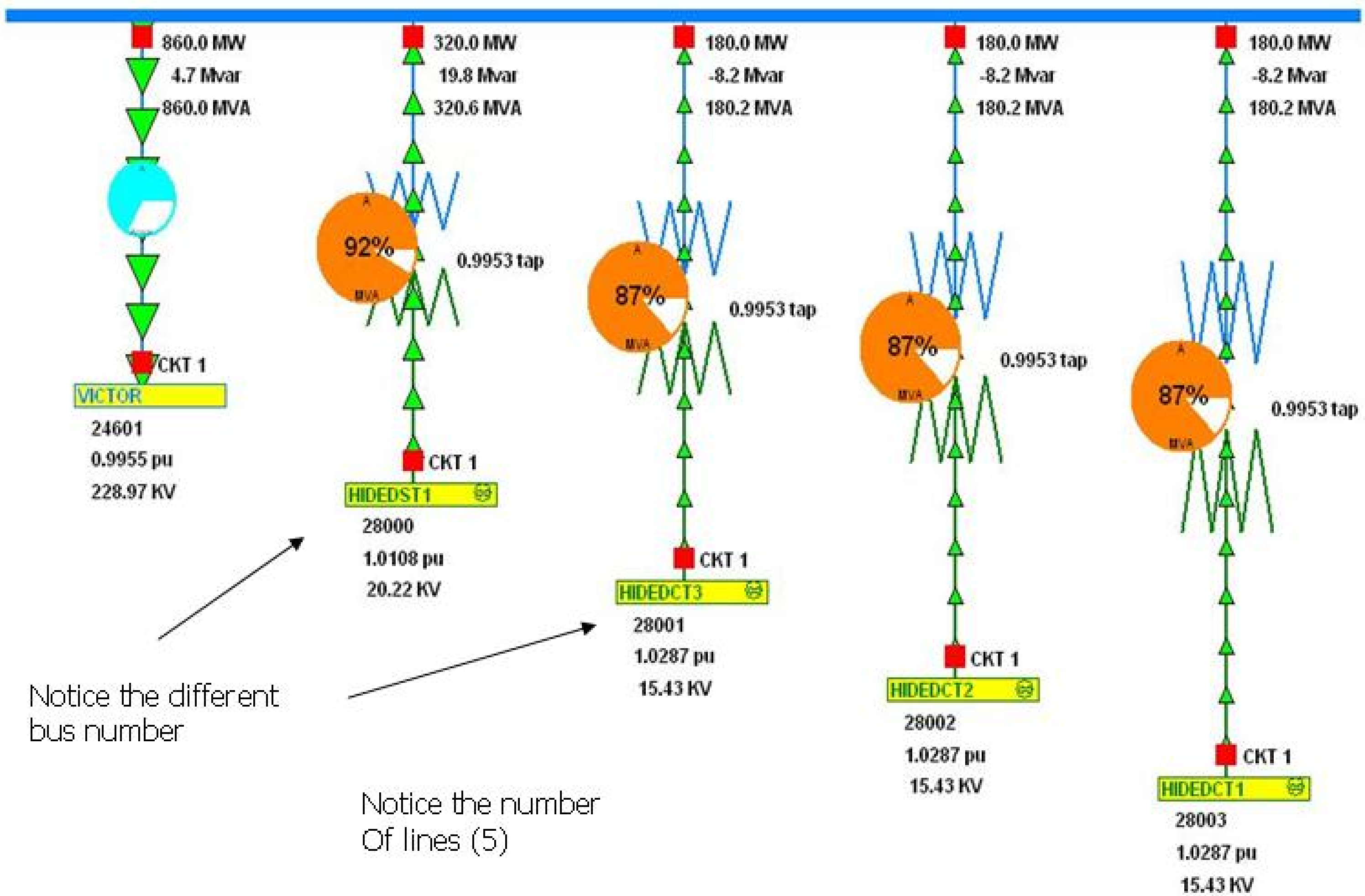
Notice the total number of lines (7)

System State

HIDESERT

Bus: HIDESERT (24350)
Nom kV: 230.00
Area: SOCALIF (24)
Zone: Zone12 (240)

1.0000 pu
230.00 KV
1.68 Deg
0.00 $/MWh



Notice the different bus number

Notice the number Of lines (5)

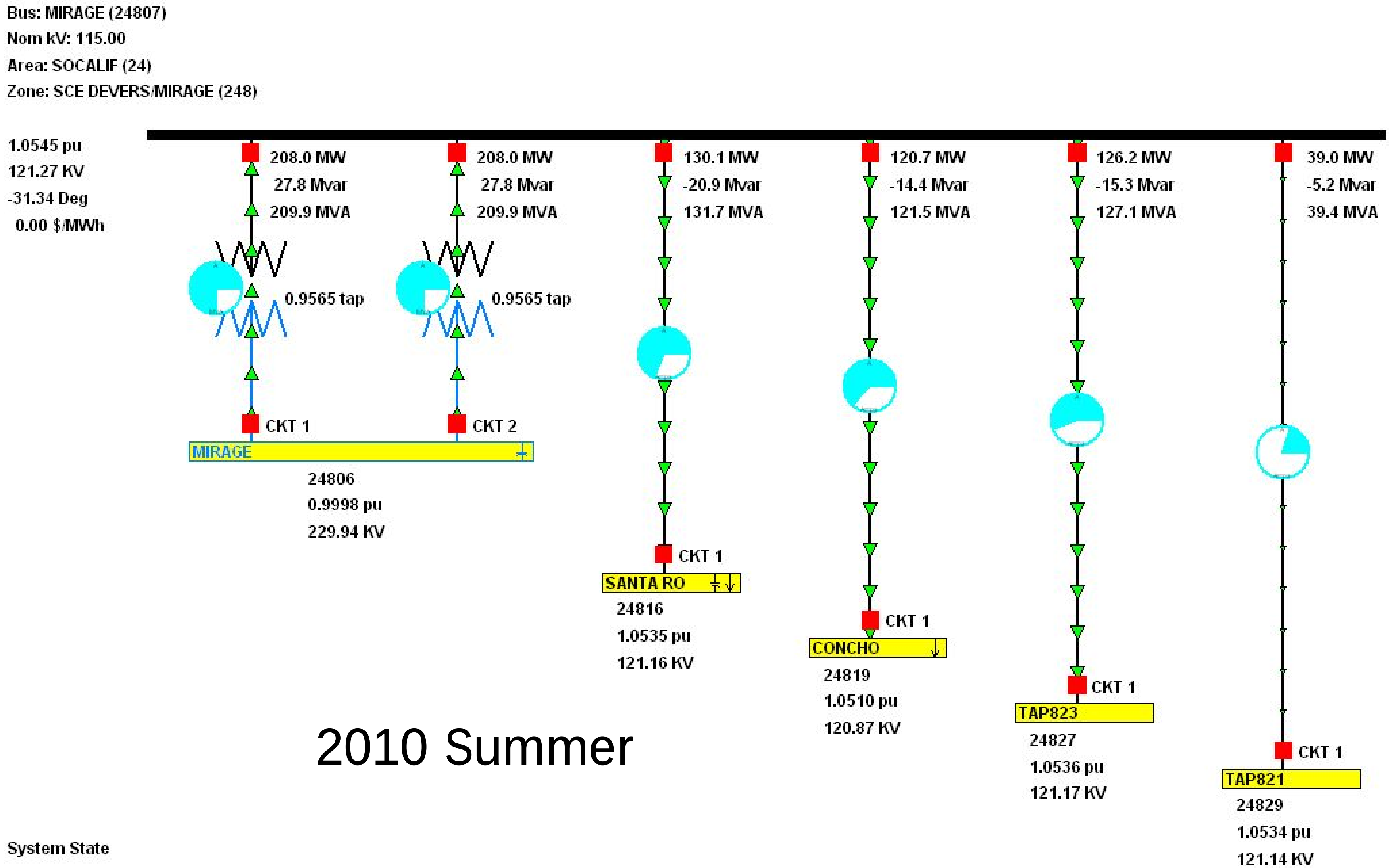
System State

2010 Summer, Spring and Fall Differences

Topology between Seasons

- 2010 data sets had different topology between 2010 summer, spring and fall
- Example is in SCE area but occurs in others utility regions as well
- 2010 summer and fall comparison

MIRAGE

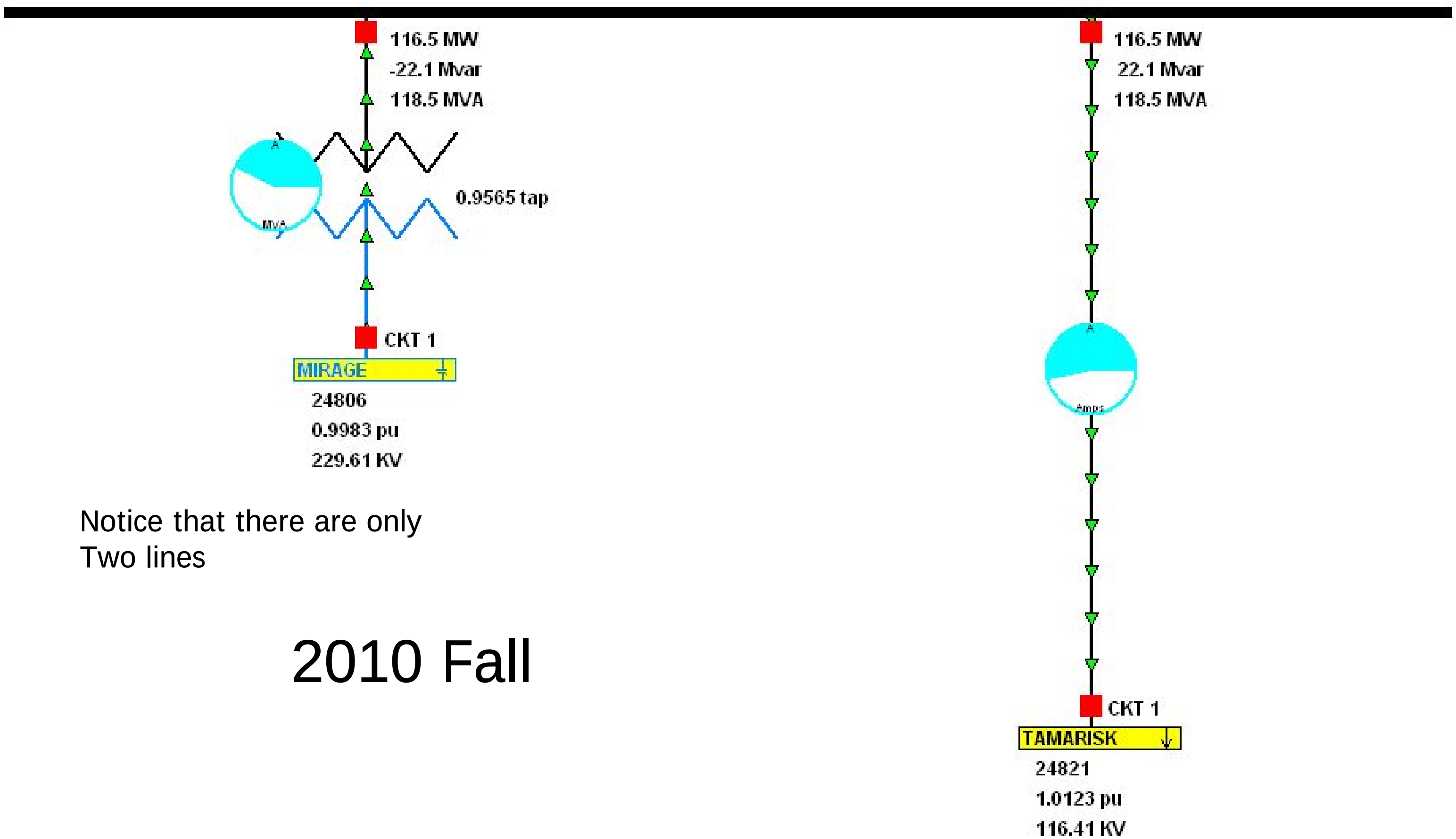


Bus: MIRAGE (24807)
Nom kV: 115.00
Area: SOCALIF (24)
Zone: SCE DEVERS/MIRAGE (248)
1.0545 pu
121.27 KV
-31.34 Deg
0.00 $/MWh
208.0 MW
27.8 Mvar
209.9 MVA
0.9565 tap
CKT 1
208.0 MW
27.8 Mvar
209.9 MVA
0.9565 tap
CKT 2
MIRAGE
24806
0.9998 pu
229.94 KV
130.1 MW
-20.9 Mvar
131.7 MVA
CKT 1
SANTA RO
24816
1.0535 pu
121.16 KV
120.7 MW
-14.4 Mvar
121.5 MVA
CKT 1
CONCHO
24819
1.0510 pu
120.87 KV
126.2 MW
-15.3 Mvar
127.1 MVA
CKT 1
TAP823
24827
1.0536 pu
121.17 KV
39.0 MW
-5.2 Mvar
39.4 MVA
CKT 1
TAP821
24829
1.0534 pu
121.14 KV
2010 Summer
System State

MIRAGE

Bus: MIRAGE (24807)
Nom kV: 115.00
Area: SOCALIF (24)
Zone: SCE DEVERS/MIRAGE (248)

1.0247 pu
117.84 KV
26.60 Deg
0.00 $/MWh



Notice that there are only
Two lines

2010 Fall

System State

Finding of Fall and Spring Cases

- Differences in configurations resulted in not using spring and fall cases
- Summer case was used as the base
- Loads, generation and interchange changed in summer case to match spring and fall power flow data sets.
- Transmission configuration used summer profiles
- Out of State matching of resources and load time consuming but matched WECC cases
- 2010 cases are consistent across seasons

Resources for meeting Reserve Margins Retirements and Load

- Additional conventional generation to meet reserve requirements, retirements and load
- Variability of renewables and low capacity factors necessitate additional generation
- Used CEC EAO production costing simulations for 20% renewable penetration to determine conventional generation needs
- Conventional resources added 1,795 MW

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2010 Conventional Resource Additions

Number	Name	Type	Fuel Type	Max MW
21026	ELCENTSW	GT	Natural Gas	50
24151	VALLEYSC	CC	Natural Gas	400
24151	VALLEYSC	CC	Natural Gas	400
26025	HAYNES	GT	Natural Gas	150
30873	HELM	CC	Natural Gas	250
30873	HELM	CC	Natural Gas	280
30875	MC CALL	CC	Natural Gas	265

Limitations to Using Power Flow Models for Renewable Studies

- Cases have high COI and other interchange flows to stress high voltage transmission
- Data sets limits ability to study for internal renewable studies
  - Limits renewable access to high voltage grid
  - Reduces generation from in-area resources
  - Could create voltage and VAR generating problems due to limited in-area resources

2010 20% Renewable Target

2010 Renewable Case Studies

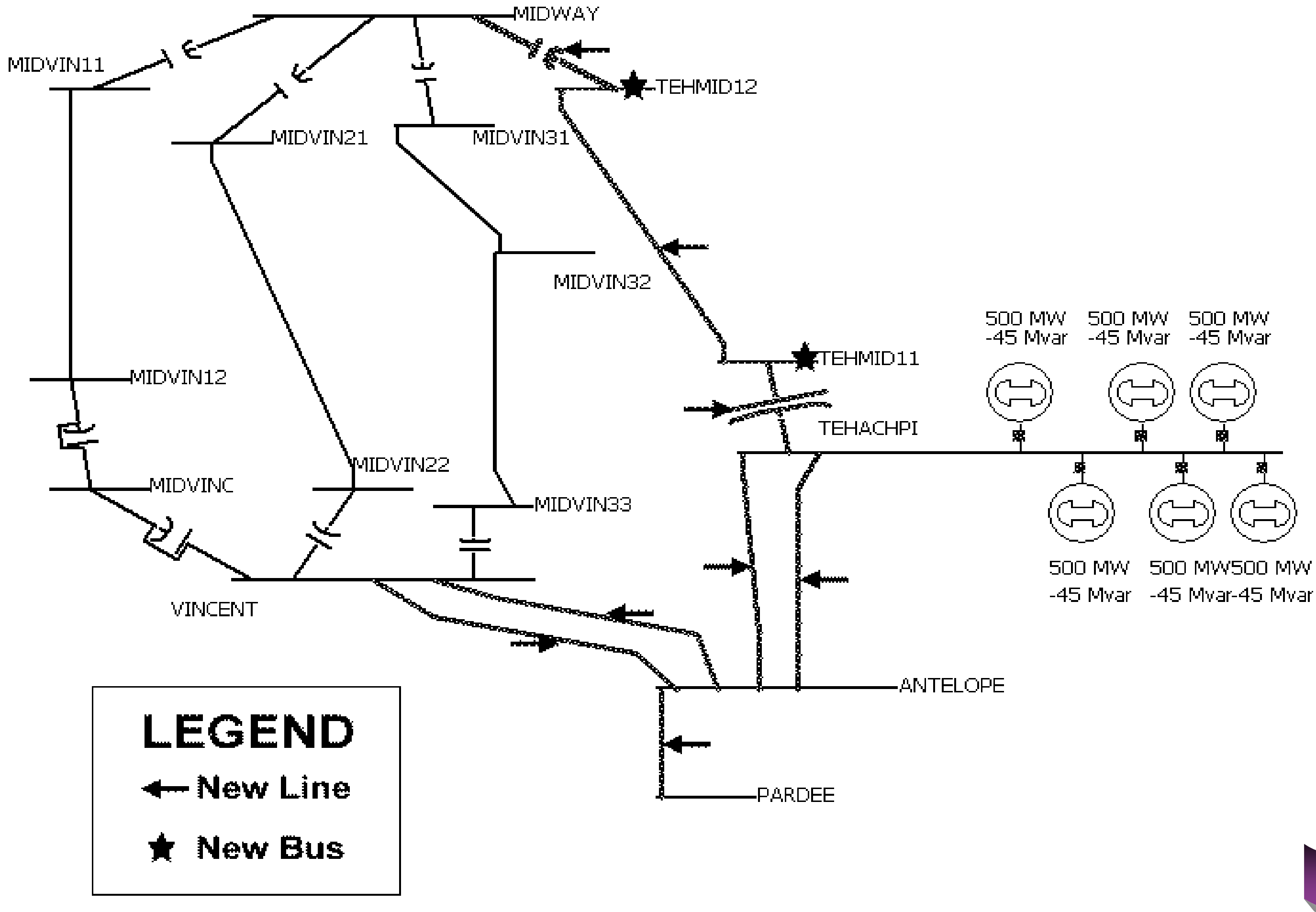
- Two 2010 Renewable Cases Developed
  - 20% Mix based on Transmission Congested; 900 MW at Tehachapi
  - 20% based on 3,000 MW at Tehachapi
  - Only Tehachapi 3,000 MW case presented here
- Strong interest by utilities to study a high Tehachapi wind penetration case

2010 Renewables
Tehachapi @ 3,000 MW

Tehachapi Modeling Assumptions

- Per recommendations from Tehachapi Wind Study Group
- New 500 kV lines
  - Tehachapi to Midway
  - Tehachapi to Antelope
  - Antelope to Vincent
  - Antelope to Pardee
  - Other 230 kV upgrades
- Did not use phase shifters
- Transmission characteristics from ISO
- 3,000 MW wind at Tehachapi substation

Tehachapi One-Line at 3000 MW



2010 Imperial Valley Modeling Assumptions

800 MW of Salton Sea development per Imperial Valley Study Group

- Upgraded IID transmission similar with IID Green Path
- Connected Salton Sea to Devers at 500 kV.
- SDG&E and LADWP have different alternatives but were not modeled here
- Alternative routes being studied under a different task outside of IAP

2010 Tehachapi Renewable Mix

Location	Technology	MW	C.F. %	Energy
Salton Sea	Geothermal	800	90.0%	6,307,200
Mount Signal	Geothermal	19	90.0%	149,796
Heber	Geothermal	42	90.0%	331,128
Brawley North	Geothermal	135	90.0%	1,064,340
Sulfur Bank	Geothermal	43	90.0%	339,012
Medicine Lake Telephone Flat	Geothermal	175	90.0%	1,379,700
Urban, Agr, Veg	Biomass	228	90.0%	1,797,552
Tehachapi	High Wind	3,000	37.0%	9,723,600
Riverside	High Wind	1,370	37.0%	4,440,444
SDGE	High Wind	150	37.0%	486,180
Solano	High Wind	275	37.0%	891,330
Altamont	High Wind	132	37.0%	427,838
LADWP Wind	High Wind	120	37.0%	388,944
All	Res Solar	500	20.0%	876,000
Other CSP	CSP	250	27.0%	591,300
SCE CSP	CSP	300	27.0%	709,560
SDG&E CSP	CSP	500	27.0%	1,182,600
Total New Resources		8,039		31,086,524

IAP

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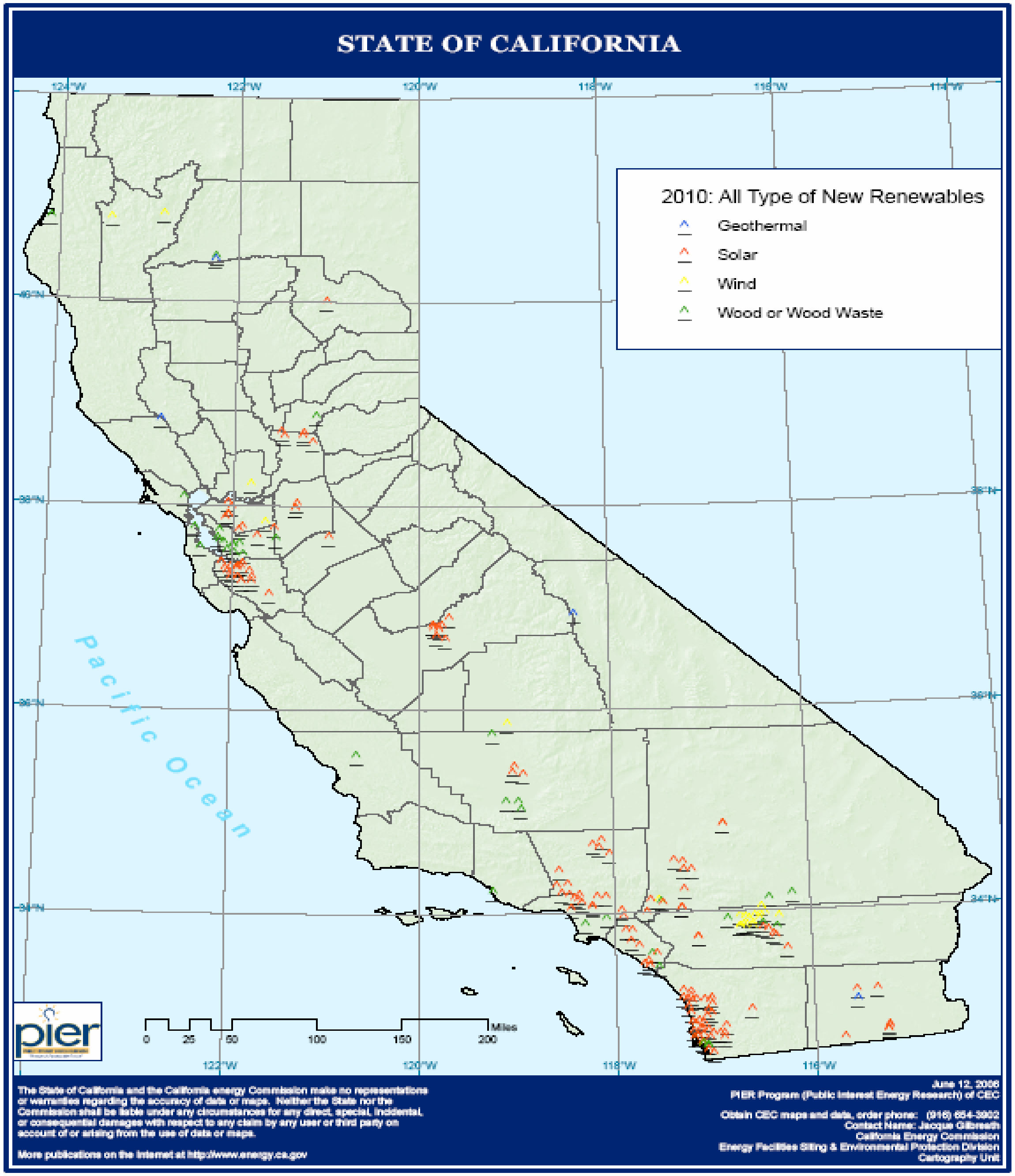
STATE OF CALIFORNIA
2010: All Type of New Renewables
Geothermal
Solar
Wind
Wood or Wood Waste
Pacific Ocean
0 25 50 100 150 200 Miles
122°W
120°W
118°W
116°W
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STATE OF CALIFORNIA
2010: All Type of New Renewables
Geothermal
Solar
Wind
Wood or Wood Waste
2006: All Type of Existing Busses
Geothermal
Solar
Wind
Wood or Wood Waste
Solar Power Plants *
* Extracted from CEC power plant data, 2000
Pacific Ocean
124°W
122°W
120°W
118°W
116°W
114°W
38°N
36°N
34°N
0
25
50
100
150
200
Miles
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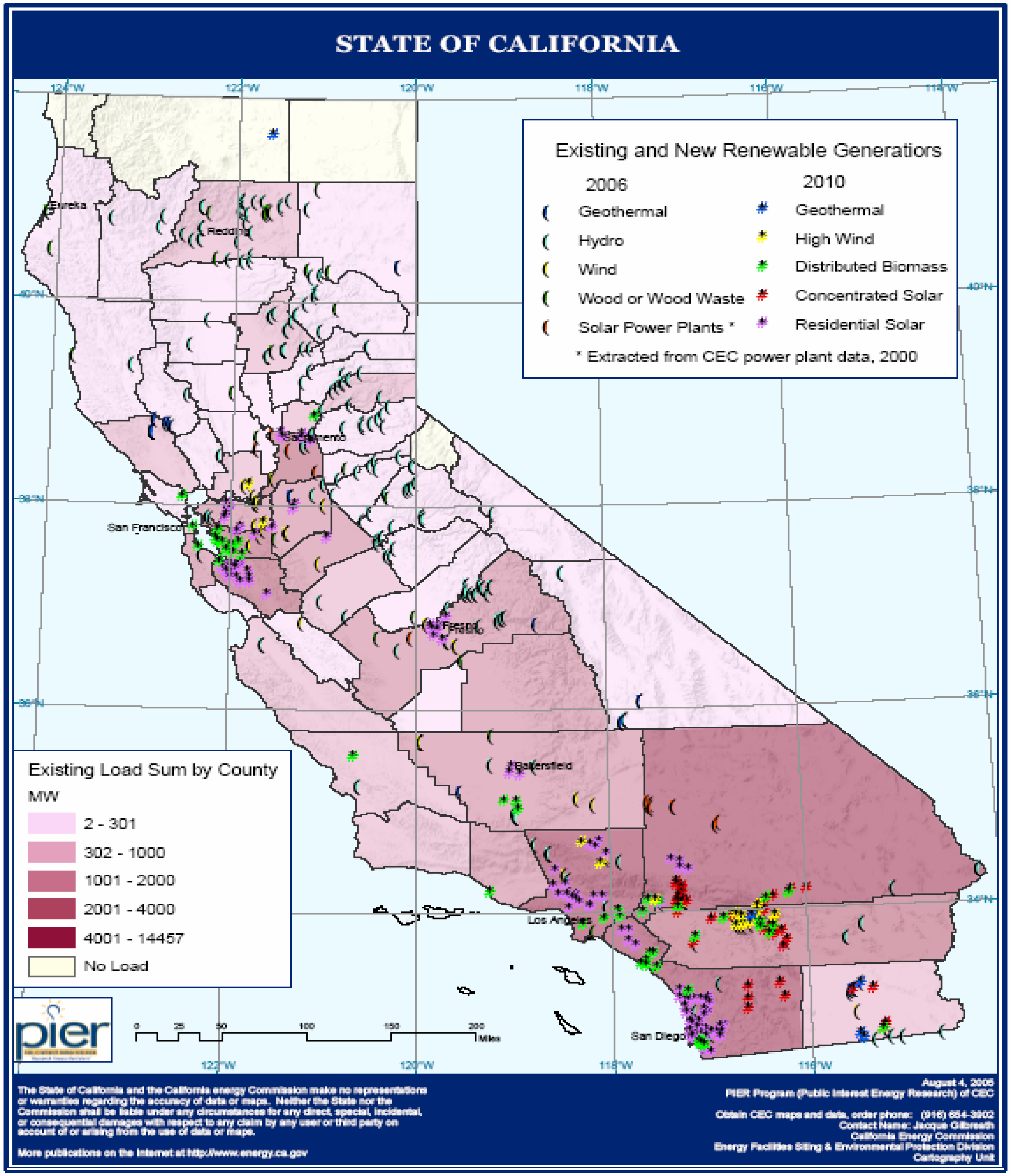
STATE OF CALIFORNIA
Existing and New Renewable Generators
2006
Geothermal
Hydro
Wind
Wood or Wood Waste
Solar Power Plants *
2010
Geothermal
High Wind
Distributed Biomass
Concentrated Solar
Residential Solar
* Extracted from CEC power plant data, 2000
Existing Load Sum by County
MW
2 - 301
302 - 1000
1001 - 2000
2001 - 4000
4001 - 14457
No Load
Eureka
Redding
Sacramento
San Francisco
Fresno
Bakersfield
Los Angeles
San Diego
0 25 50 100 150 200 Miles
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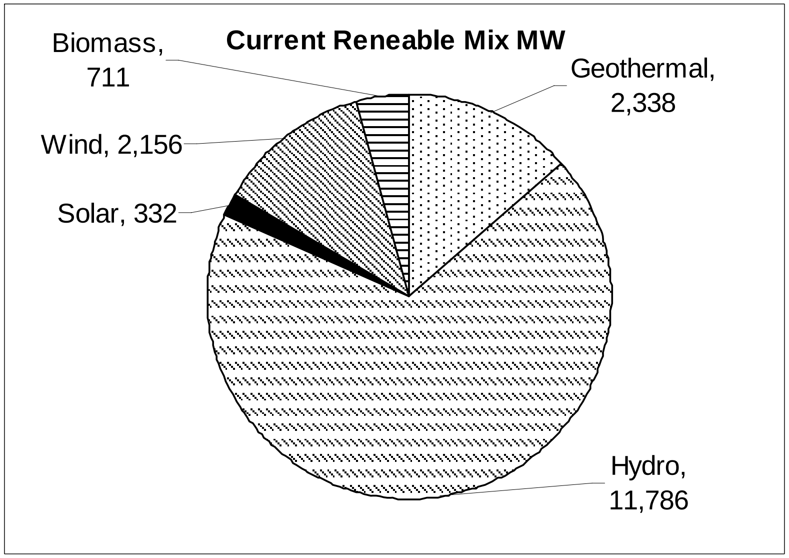
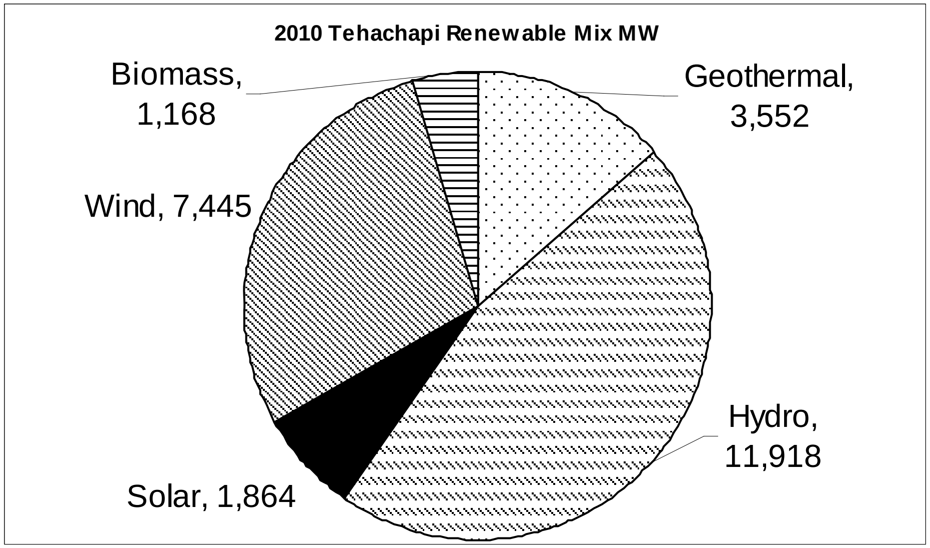
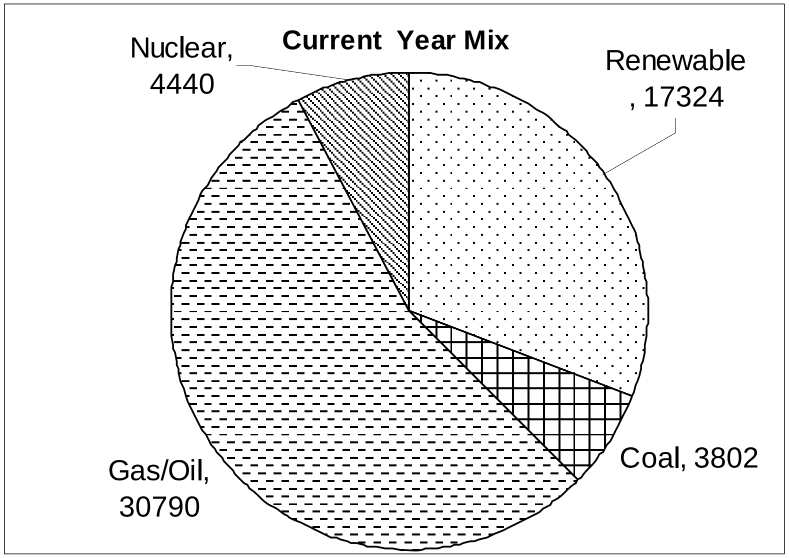
Current Year and 2010 Tehachapi Renewable Mix

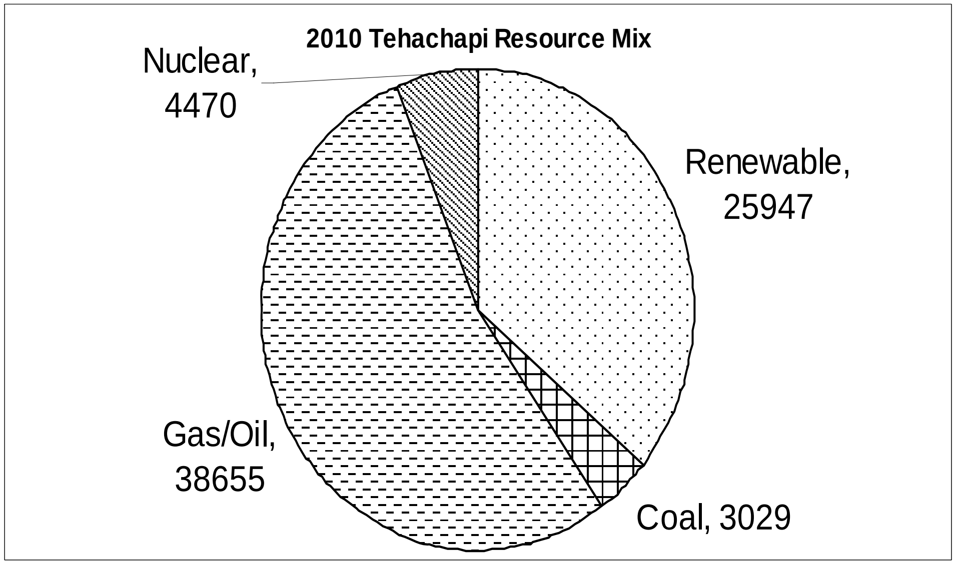




Hydro MW different between cases due to upgrades in system and not due to renewable portfolio mix

Current Year and 2010 Tehachapi Resource Mix

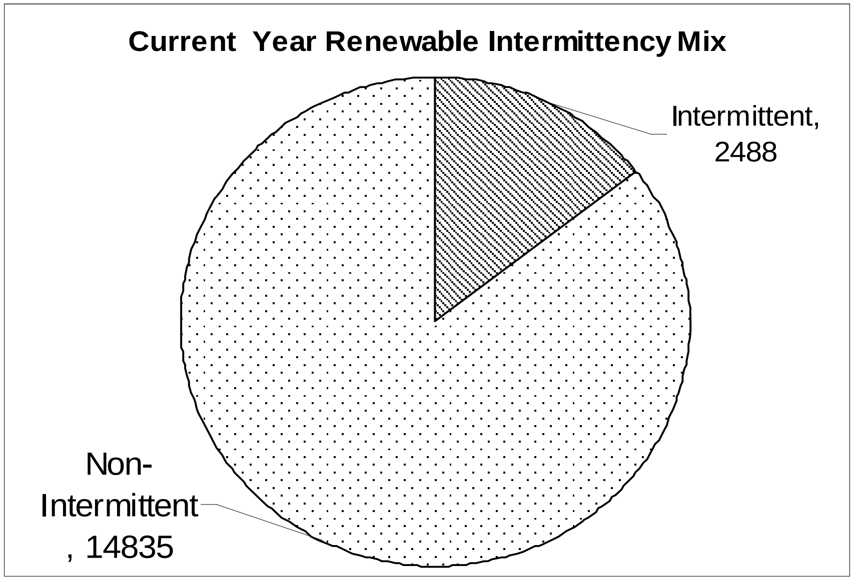


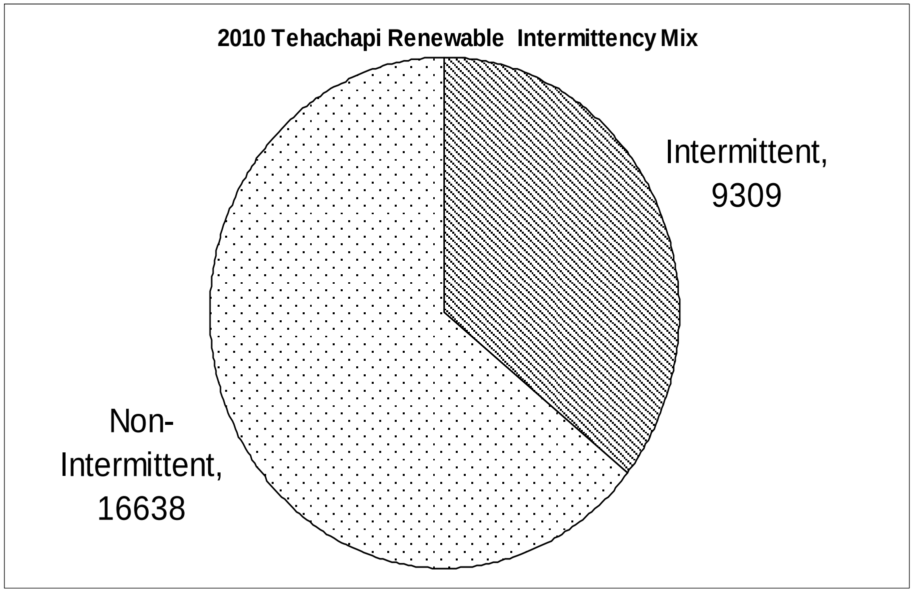


Total MW 56,356

Total MW 72,101

Current Year and 2010 Tehachapi Renewable Intermittency Mix





2010 Tehachapi Case Transmission Results

Voltage	Line Segments	Transformers
500	8	2
230	8	6
161	0	1
115	49	9
Below 110	13	14
Total	78	32

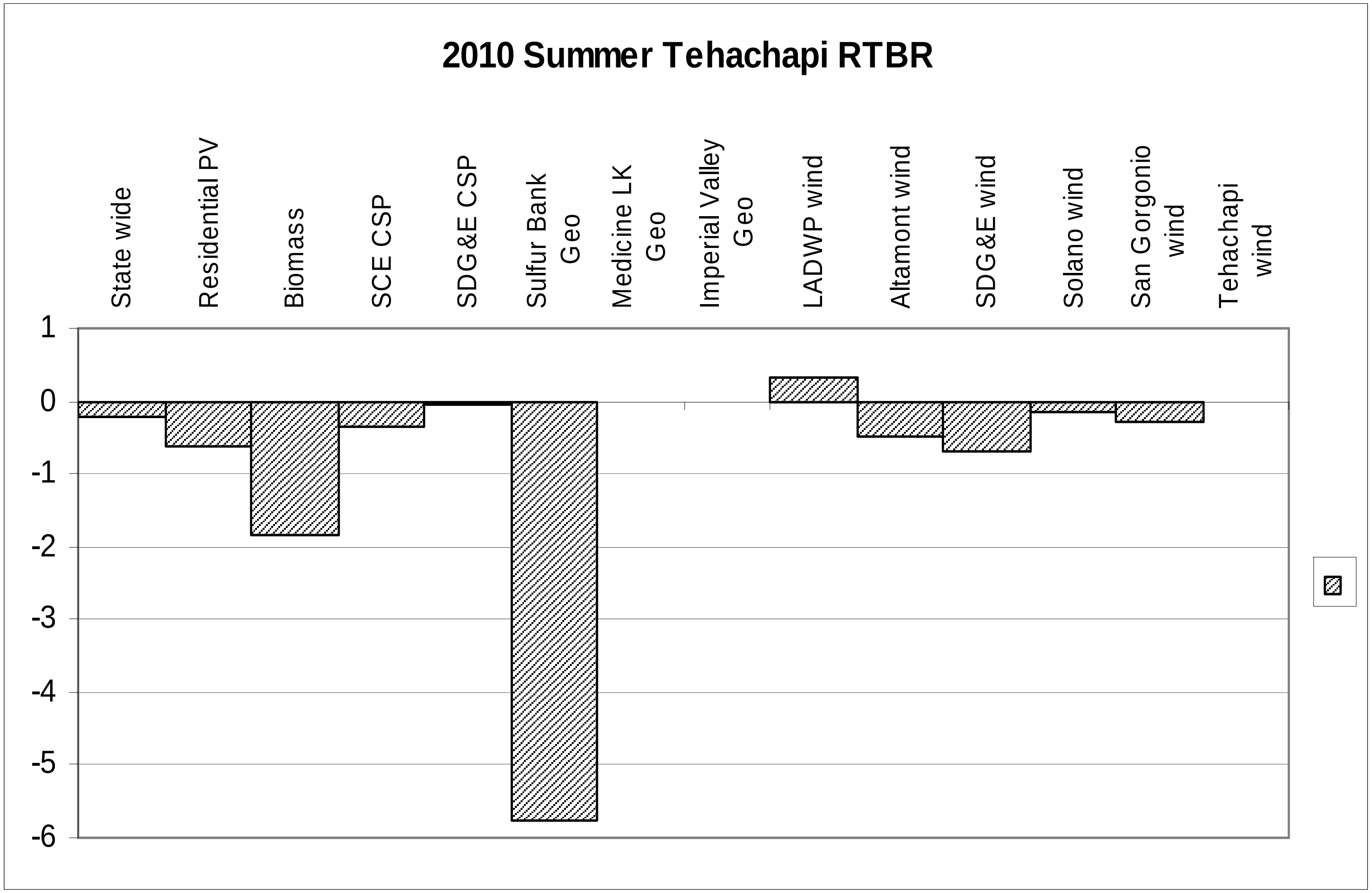
Historical Year to 2010 Tehachapi Transmission 60% Wind

	Historical Year Summer	2010 Tehachapi Summer	2010 Tehachapi Spring	2010 Tehachapi Fall
Non-Radial Overloads	10	5	2	0
Radial Overloads	38	8	2	3
Non-Radial High Voltage	14	0	7	0
Radial High Voltage	10	7	11	6
Non-Radial Low Voltage	22	0	0	0
Radial Low Voltage	18	1	1	1

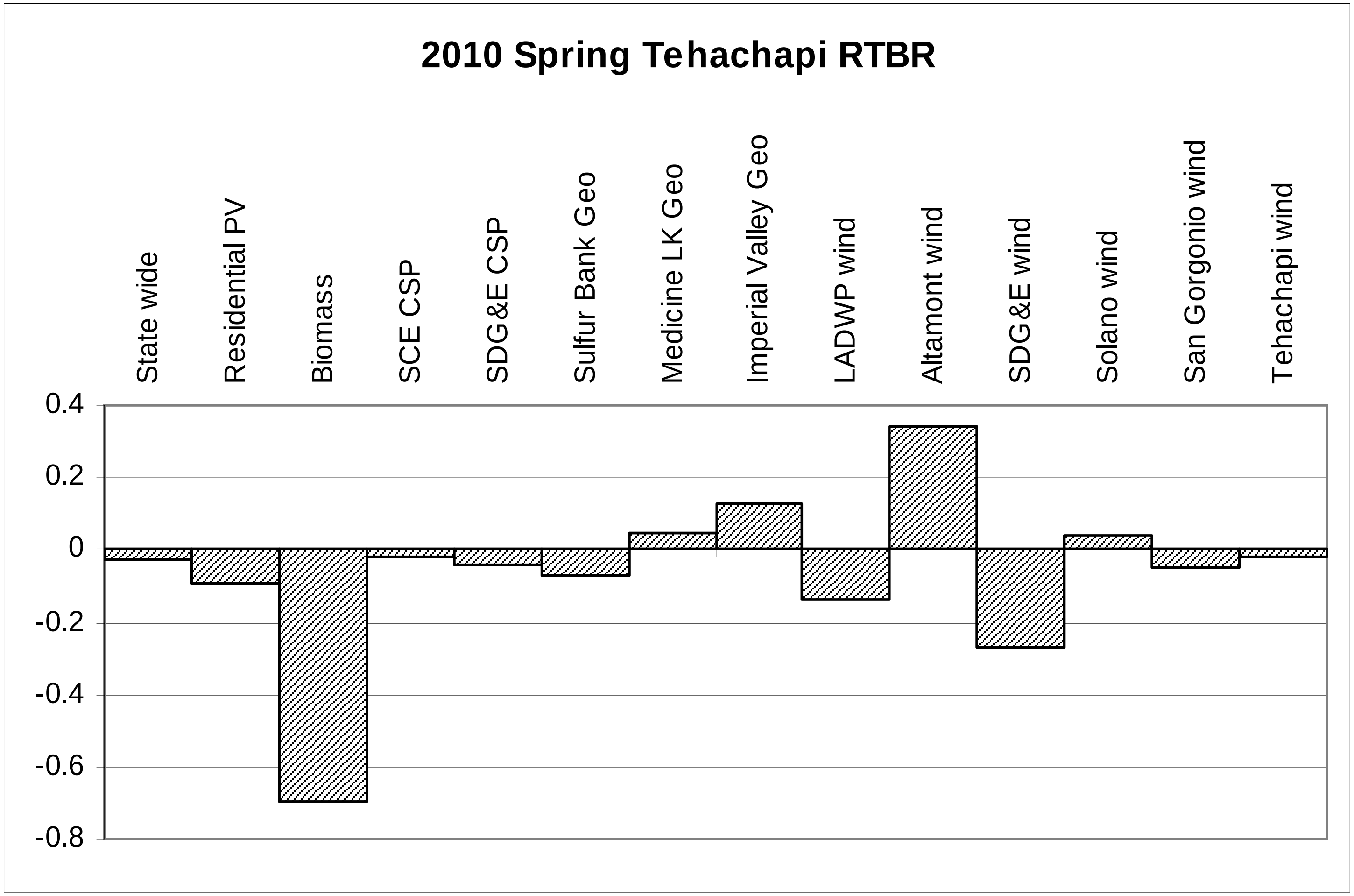
Transmission Benefit Ratio

- Calculation process
  - Started with the base case w/existing renewables
  - Added renewable technology incrementally
  - Run power flow to obtain benefit ratios for each additional renewable
  - Incremental addition is added to the previous simulation
  - Positive bad, negative good

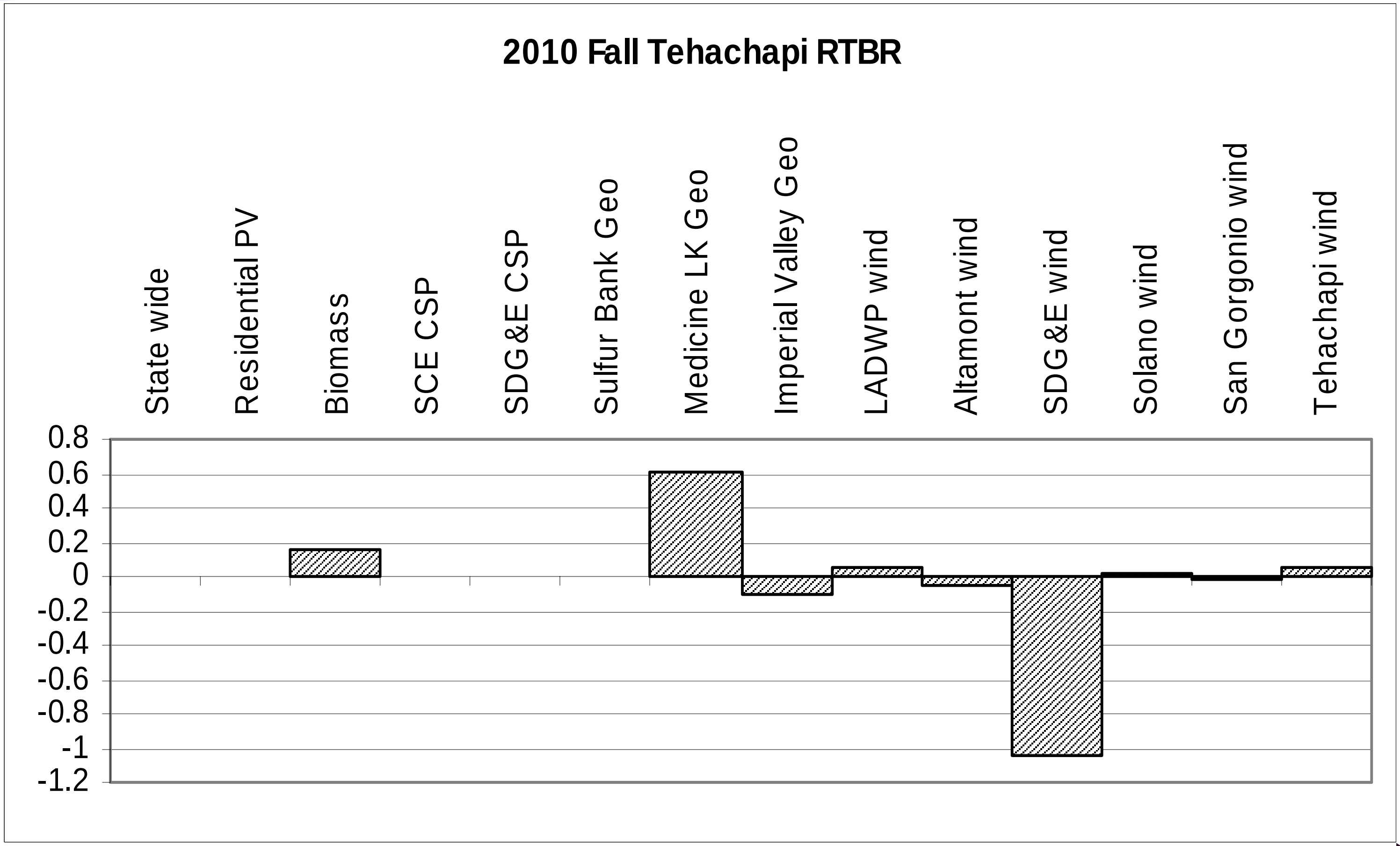
2010 Summer Tehachapi RTBR



2010 Spring Tehachapi RTBR



2010 Fall Tehachapi RTBR



2010 Renewable Sites with Positive RTBR

Renewable Site	Summer Positive	Spring Positive	Fall Positive
LADWP Wind	XXX		XXX
Medicine Lake Geo		XXX	XXX
Imperial Valley Geo		XXX	
Altamont Pass Wind		XXX	
Solano Wind		XXX	
Biomass			XXX
Tehachapi Wind			XXX

Reasons for Positive RTBR

- Did not exhaust transmission expansion requirements
- Spring hydro conditions did cause issues associated with northern CA 500 kV power flows
- Fall had minimum load and high SP15 south to north flows

Observations/Conclusions

- Needed to build a consistent seasonal cases based on WECC
  - Time of development and data request timing inconsistent
- Voltage and VAR flows still a concern
- Multiple year trending analysis can eliminate or reduce impacts from power flow modeling errors and discrepancies

Recommendations

- Need for a detailed VAR flow study
- Complete an analysis on VAR flows and impacts to RMR, voltage and line loading
- Consider developing CA data sets that more closely model subregional conditions

Next Steps

- Include a Time step power flow modeling
  - Benefits
- Complete the Task 3 reports
  - Time line

Questions ????